HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT
Review Comments Form

Submittal/Document Title: **Pearl Highlands Ramp Impact Report**	Reviewer: **HDOT / FHWA**	Date: **12-22-09**

Response Code:	A - Agree and will comply	B - Will investigate and comment	C - Clarification needed	D - Disagree for reasons noted	E – No action Needed

Comment No.	Reference	Comment	Responsible Party	Response Code	Response:	Reviewer's Concurrence	Verification of Incorporation
1		If the intent of the report was to address any fatal flaws in the request, provide in the report emphasis on the geometrics of the ramps such as the decision sight distance to new direct access ramp on the existing H-2 Southbound to H-1 Westbound ramp and evaluation of the existing H-2 Northbound On-ramp versus AASHTO versus proposed re-striping.	Shimizu	B	Inserted the following explanatory text: "A minimum decision sight distance of 1280 feet is required according to AASHTO for a design speed of 60 mph on an urban roadway. More than 2100 feet of sight distance is available measured from the center of the direct access ramp lane right of the exit nose for existing H-2 Southbound to H-1 Westbound ramp." "The proposed restriping of the existing H-2 Northbound On-ramp lanes proposed 11'-wide lanes, a 2' wide shoulder on the left side and an 3'-wide shoulder on the right side at the narrowest cross section. AASHTO Policy on Geometric Design of Highways and Streets state that 12'-wide lanes and 10' wide shoulders should be provided. Approval from the design exceptions from FHWA would need to be obtained, even though other AASHTO references, such as the Guide for High-Occupancy Vehicle (HOV) Facilities, suggest certain conditions make it appropriate to reduce freeway lane widths to 11' and shoulder widths to 2'."		

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2		The report should also consider the 2030 analysis of the merge condition at the end of the H-2 Southbound to H-1 Westbound ramp that could be created by the additional H-1Westbound lane through Waiawa I.C.	Hong	B	Inserted the following explanatory text: "One of the design alternatives of the PM zipper lane project is to widen westbound H-1 from 3 lanes to 4 between Kamehameha Highway westbound ramp to H-2 Southbound ramp. This will potentially produce a merge condition at the end of the H-2 Southbound to H-1 Westbound ramp. Additional analysis may be required when detailed design plans for the H-1 project are available."		
3		The 1:1 reduction or net change in volume will probably not occur due to latent demand, therefore adjust the change in volume accordingly.	Shelton	D	Latent demand is a complex modeling issue, and changing volume assumptions would be inconsistent with other traffic forecasting assumptions in the EIS. However, a sensitivity analysis was conducted which assumed no volume reductions on the H-2 mainline. This sensitivity analysis reached similar LOS findings. This has been noted in the memo.		
4		In Section 4, using AMFs for rural 2-lane highways is not appropriate for Freeway ramps since the SPFs are derived based on similar	Shelton	A	Removed figures and revised text as follow:. "…based on review of accident modification factors for rural		

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		type roadways.			highways, the reduction in lane and shoulder widths on the bridge could increase the potential for accidents. While this is a different type of facility from a rural two-lane highway, similar effects of narrowing lane and shoulder widths could be expected on a freeway. Overall, the proposed mitigation is expected to result in a trade-off related to safety: an improvement due to the increased merge distance and a degradation due to the narrower lanes and shoulders."		
5		A 30% increase in accidents for the proposal to drop shoulders from 10' to 2' is significant. Do not say it is 'not significant.'	Shelton	A	In response to comment 4, AMF figures were removed and text revised (see response to comment 4 for more details).		
6		Provide in the report a feasibility analysis for not constructing the H-2 Northbound On-ramp in accordance with AASHTO standards.	Shimizu	D	A feasibility analysis for not reconstructing the H-2 Northbound On-ramp to full AASHTO freeway standards will be submitted later as part of an official request for approval of a design exception.		
7	H-2 Northbound On-Ramp	Increase traffic volumes on the on-ramp is not equivalent to a reduction in mainline traffic volumes. To characterize the "net reduction of approximately 100 cares at the merge	Shelton	A	Inserted additional text as follows: "While the overall volume of vehicles at this merge point will be reduced, the increase in vehicles merging with the mainline would be expected to have a negative impact on		

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		junction" as a simple arithmetic comparison is, therefore, misleading and inappropriate. The significant increase in the number of cars that must merge into mainstream traffic has far greater impact and influence on operations that the relatively small percent decrease in mainline traffic volumes.			operations."		
8		It is questionable that the traffic projections conducted for the much larger regional transit system is appropriate for site specific traffic impacts as assumptions made at the regional level are highly speculative when applied at a sight specific location for operational analyses.	Shelton	D	Revised text to better explain assumptions and methodology regarding traffic volumes, including the following clarifying text: "Year 2030 No Build Alternative volumes for the freeway mainline, ramps, and nearby highways were estimated by applying a growth rate to existing counts. The growth rate was derived from Project travel demand model volumes for Existing Year (2007) and Year 2030. Project scenario volumes were then developed based on anticipated trip volumes to and from the rail station, as well as examination of travel demand model volume changes forecasted between the No Build and		

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Comment No.	Reference	Comment	Responsible Party	Response Code	Response:	Reviewer's Concurrence	Verification of Incorporation
					Project scenarios. Station-related trip volumes consisted of forecasted attractions to and from the park-and-ride facility (based on the travel demand model) as well as anticipated transit vehicle volumes identified as part of the Project scenario. Differences in volumes between the 2030 Baseline and 2030 Build travel demand model forecasts were used as a basis for developing site-specific volume projections for the study area. The differences in the travel demand model volumes were investigated to evaluate how the rail project would affect volumes on the freeway mainline and ramps, as well as local arterials. Roadway volumes were then manually adjusted using the model output in combination with knowledge of the local area and access routes to/from the park-and-ride facility."		
9		Reduction in lane widths and shoulders will also significantly impact traffic operations, creating a constriction and increased congestion upstream of the H-1/H-2 diverge, therefore include in the report the evaluation and address the	Shelton	A	Revised text to include analysis of freeway ops with reduced lane and shoulder widths. Inserted the following text: "In addition to safety effects, the narrowing of lanes and shoulders will have some effect on operations. Accordingly, HCS analysis was		

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		traffic operations in addition to safety.			performed for the freeway segment following the merge for AM and PM peak hours, comparing the No Build condition to the proposed restripe. The results are presented in Table 3, and the HCS analyses are included in Appendix B. The table indicates that, although there are operational effects from narrower lane widths and shoulders, the effect of adding a lane would overcomes the other effects, to resulting in a net improvement in operations over the bridge."		
10		Report inappropriately applies "rural two-lane highway" safety performance to high speed freeway operations. Application and relevance of such analyses are questionable. Conclusion that narrowing of shoulders and lanes may result in a "slightly higher potential for accidents" is, therefore, inappropriately based on flawed analyses. At the very least, the report should specifically identify this discrepancy. (see comment #4)	Shelton	A	In response to comment 4, AMF figures were removed and text revised (see response to comment 4 for more details).		
11		Question whether the report	Shelton	A	Provided the following additional text:		

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		appropriately accounts for increased bus usage on the ramp as heavy vehicles will significantly impact operations (difficult to see calculations, blurry). If buses aren't forecast to use this ramp, what guarantee will City provide that buses will never ever use this ramp and if buses are using other routes, has similar impact analyses been done on those routes.			"The reduction in vehicle trips is expected to result in additional trips taken by bus on H-2. Approximately 32 buses are expected to use the ramp during the PM peak hour with the Project, while none currently use the ramp (this is reflected in the HCS analysis, as shown in Appendix B)."		
12		If report assumes 300 vehicle reduction in traffic volumes on H-2 Freeway, then those trips must have transferred on to buses since transit does not serve Waipio, Mililani, Wahiawa, and the Northshore. What route will such bus service take? If not this ramp then what other ramp?	Shelton	A	See response to comment 11.		

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Pearl Highlands Station Freeway Ramp
Operational and Safety Analysis Report
Honolulu High-Capacity Transit Corridor Project

March 3, 2010

Prepared for:
City and County of Honolulu

1 Introduction

This report provides an operational and safety analysis of freeway ramps and segments near the proposed Pearl Highlands Station. It also discusses proposed modifications to the highway system that include additional access and design exceptions. There are two interstate access modifications proposed with the Honolulu High-Capacity Transit Corridor Project (Project):

- A new direct access ramp from the H-2 Freeway to a park-and-ride and transit center to serve commuters from Central O'ahu—the ramp would diverge from the existing ramp from southbound H-2 to westbound H-1.

- A revised access ramp to northbound H-2 at Kamehameha Highway—the Project would restripe the existing H-2 lane configuration to extend the on-ramp merge lane by approximately 500 feet.

This report serves as the first step in the Interstate Access Modification Request process that will need to be approved by the Federal Highway Administration (FHWA). A full eight-point Access Modification Study will be completed after the Project Record of Decision.

2 Methodology

Year 2030 No Build Alternative volumes for the freeway mainline, ramps, and nearby highways were estimated by applying a growth rate to existing counts. The growth rate was derived from Project travel demand model volumes for Existing Year (2007) and Year 2030. Project scenario volumes were then developed based on anticipated trip volumes to and from the rail station, as well as examination of travel demand model volume changes forecasted between the No Build and Project scenarios. Station-related trip volumes consisted of forecasted attractions to and from the park-and-ride facility (based on the travel demand model) as well as anticipated transit vehicle volumes identified as part of the Project scenario. Differences in volumes between the 2030 Baseline and 2030 Build travel demand model forecasts were used as a basis for developing site-specific volume projections for the study area. The differences in the travel demand model volumes were investigated to evaluate how the rail project would affect volumes on the freeway mainline and ramps, as well as local arterials. Roadway volumes were then manually adjusted using the model output in combination with knowledge of the local area and access routes to/from the park-and-ride facility. Ramp merge sections were analyzed using Highway Capacity Software (HCS) (version 5.21). Existing accident data was obtained from the Hawai'i Department of Transportation (HDOT).

3 Analysis of the H-2 Southbound Freeway Off-ramp

As shown in Appendix A, a new ramp is proposed to provide direct auto and bus access from the off-ramp from southbound H-2 to westbound H-1 into the Pearl Highlands Station park-and-ride and transit center. The 2030 volumes on the existing H-2 to H-1 ramp are anticipated to be approximately 240 vehicles in the AM peak hour and 40 vehicles in the PM peak hour. The new ramp would diverge from the existing southbound off-ramp from H-2 to westbound H-1 and Waipahu Street (the split to these two destinations occurs after the diverge of the new ramp). The existing southbound H-2 to westbound H-1 ramp exits H-2 as a drop lane as opposed to a diverge, with a posted speed of 45 mph. This results in an approximate capacity of 2,100 vehicles per hour according to the Highway Capacity Manual (2000). Table 1 summarizes current and future projected ramp volumes. With a 2030 No Build volume of 415 vehicles in the AM peak hour, the volume-to-capacity (v/c) ratio of 0.19 indicates an approximate level of service (LOS) of A. The additional 240 vehicles accessing the new ramp would bring the total volume on the off-ramp to 655 vehicles, which would result in a v/c ratio of 0.31 and an estimated LOS B. In the PM peak hour, the 2030 No Build volume of 950 vehicles would be increased to 990 with the anticipated volumes accessing the station. This is anticipated to result in the operations on the ramp remaining at LOS C.

The impacts on safety from the additional traffic on the ramp are anticipated to be minimal. With a v/c ratio of less than 0.50 during both the AM and PM peak hours, the impact on congestion and resulting increase in likelihood of accidents is expected to be minimal with the proposed new ramp and accompanying volume.

A minimum decision sight distance of 1,280 feet is required, according to AASHTO for a design speed of 60 mph on an urban roadway. More than 2,100 feet of sight distance is available, measured from the center of the direct access ramp lane right of the exit nose for the existing H-2 southbound to H-1 westbound ramp.

Also, one of the design alternatives of the PM zipper lane project is to widen westbound H-1 from 3 lanes to 4 between Kamehameha Highway westbound ramp to H-2 southbound ramp. This will potentially produce a merge condition at the end of the H-2 southbound to H-1 westbound ramp. Additional analysis may be required when detailed design plans for the H-1 project are available.

In conclusion, no significant operational or safety impact to the existing off-ramp or mainline traffic is anticipated to occur with construction of the proposed direct access ramp.

Pearl Highlands Station Freeway Ramp Operational and Safety Analysis Report
Honolulu High-Capacity Transit Corridor Project

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AR00113818

Table 1: H-2 Southbound Traffic Volumes

	Current Traffic Volume	2030 No Build Traffic Volume	2030 Project Traffic Volume	Net Change in Volume: Project vs. No Build
AM Peak Hour				
H-2 Southbound Total	**4,885**	**5,440**	**5,440**	**0**
H-2 to H-1 Westbound/Waipahu St[1]	365	415	655	240
H-2 to H-1 Eastbound	4,520	5,025	4,785	-240
PM Peak Hour				
H-2 Southbound Total	**3,300**	**3,750**	**3,750**	**0**
H-2 to H-1 Westbound/Waipahu St	840	950	990	40
H-2 to H-1 Eastbound	2,460	2,800	2,760	-40

Notes:
1 Additional volumes exit ramp on new direct access ramp and do not enter H-1 Westbound or Waipahu Street.

Pearl Highlands Station Freeway Ramp Operational and Safety Analysis Report
Honolulu High-Capacity Transit Corridor Project

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AR00113819

4 Analysis of the H-2 Northbound Freeway On-ramp from Westbound Kamehameha Highway

As shown in Table 2 and Appendix A, construction of the Project is anticipated to result in an increase in the 2030 volume during the PM peak hour on the on-ramp from westbound Kamehameha Highway to northbound H-2. As shown in Appendix B, an analysis of this ramp merge in HCS indicated that, without construction of the Project (No Build), ramp operations are expected to be LOS F in 2030 during the PM peak hour. This is due to a combination of high traffic volumes (3,545 vehicles on the mainline merging with 860 entering vehicles from the Kamehameha Highway on-ramp), a relatively sharp on-ramp angle (approximately 25:1), and a relatively steep upgrade directly after the ramp merge. The Project will result in an addition of approximately 200 vehicles to the Kamehameha Highway on-ramp and a reduction of approximately 300 vehicles on the H-2 mainline[1], resulting in a net reduction of approximately 100 cars at the merge junction. While the overall volume of vehicles at this merge point will be reduced, the increase in vehicles merging with the mainline would be expected to have a negative impact on operations. The reduction in vehicle trips is expected to result in additional trips taken by bus on H-2. Approximately 32 buses are expected to use the ramp during the PM peak hour with the Project, while none currently uses the ramp (this is reflected in the HCS analysis, as shown in Appendix B). With the Project, this merge is expected to continue to operate at LOS F. As a sensitivity analysis, HCS analysis was also conducted with the conservative assumption of no reduction in volumes on the H-2 mainline, with a similar finding of LOS F.

To mitigate for the potential increase in merging traffic, the Project will restripe the section of H-2 near the ramp merge area to provide a parallel merge lane that will continue for approximately 500 feet across an existing bridge. To accomplish this, the existing lanes will be narrowed from 12 feet to 11 feet, the inside shoulder will be reduced from 4 feet to 2 feet, and the outside shoulder from 10 feet to 3 feet. The proposed restriping is shown in Appendix C.

The proposed restriping of the existing H-2 northbound on-ramp lanes proposed 11-foot wide lanes, a 2-foot wide shoulder on the left side and an 3-foot wide shoulder on the right side at the narrowest cross section. AASHTO Policy on Geometric Design of Highways and Streets states that 12-foot wide lanes and 10-foot wide shoulders should be provided. Approval for design exceptions from FHWA would need to be obtained, even though other AASHTO references, such as the Guide for High-Occupancy Vehicle (HOV) Facilities, suggest certain conditions make it appropriate to reduce freeway lane widths to 11 feet and shoulder widths to 2 feet.

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1 It is assumed that these trips would now be made on the new rail line and then transfer to cars or buses using the on-ramp from Kamehemeha Highway.

Pearl Highlands Station Freeway Ramp Operational and Safety Analysis Report
Honolulu High-Capacity Transit Corridor Project

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A review of HDOT accident history indicated that one accident occurred where the ramp from westbound Kamehameha Highway meets northbound H-2 between 2004 and 2006. Thus, this is not considered a *high-accident location*, which is defined as a location with at least three accidents per year for 3 consecutive years. With the elimination of the existing sharp-angle merge, the proposed mitigation is anticipated to result in a safer operating environment at this location, as vehicles entering from westbound Kamehameha Highway will have more time and distance (as well as better sight distance) to merge with vehicles on the mainline. Longer acceleration lanes have been recommended as a method of increasing safety on short curve on-ramps.[2] It also should be noted that, based on review of accident modification factors for rural highways, the reduction in lane and shoulder widths on the bridge could increase the potential for accidents.[3] While this is a different type of facility from a rural two-lane highway, similar effects of narrowing lane and shoulder widths could be expected on a freeway. Overall, the proposed mitigation is expected to result in a trade-off related to safety: an improvement due to the increased merge distance and a degradation due to the narrower lanes and shoulders.

In addition to safety effects, the narrowing of lanes and shoulders will have some effect on operations. Accordingly, HCS analysis was performed for the freeway segment following the merge for AM and PM peak hours, comparing the No Build condition to the proposed restripe. The results are presented in Table 3, and the HCS analyses are included in Appendix B. The table indicates that, although there are operational effects from narrower lane widths and shoulders, the effect of adding a lane would overcome the other effects, resulting in a net improvement in operations over the bridge. Again, as a sensitivity analysis, HCS analysis was also conducted with the conservative assumption of no reduction in volumes on the H-2 mainline, with similar LOS findings.

In summary, the narrowing of shoulders and lane widths may result in a higher potential for accidents, but eliminating the sharp-angle merge and providing a longer acceleration lane for the merge is expected to increase safety and reduce the potential for accidents, while also improving operations in the area of the bridge.

Table 2: H-2 Northbound Traffic Volumes

	Current Traffic Volume	2030 No Build Traffic Volume	2030 Project Traffic Volume	Net Change in Volume: Project vs. No-Build
AM Peak Hour				
H-1 Westbound to H-2 Northbound	1,560	1,770	1,720	-50
Kamehameha Hwy. Westbound to H-2 Northbound	270	515	470	-45

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[2] McCartt, A.T., et al. 2004. "Types and characteristics of ramp-related motor vehicle crashes on urban interstate roadways in Northern Virginia." *Journal of Safety Research 35.*

[3] U.S. Department of Transportation. December 2000. *Prediction of the expected safety performance of rural two-lane highways.*

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H-2 Northbound Total	1,830	2,285	2,190	-95
PM Peak Hour				
H-1 Westbound to H-2 Northbound	3,125	3,545	3,245	-300
Kamehameha Hwy. Westbound to H-2 Northbound	475	860	1,060	200
H-2 Northbound Total	3,600	4,405	4,305	-100

Table 3: H-2 Northbound Post-Merge Freeway LOS

	2030 No Build LOS	2030 Project LOS
AM Peak Hour	C	B
PM Peak Hour	F	D

Pearl Highlands Station Freeway Ramp Operational and Safety Analysis Report
Honolulu High-Capacity Transit Corridor Project

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Appendix A—Volume Diagrams

Figure A-1. Existing Conditions

Existing Conditions
(xxxx) AM
xxxx PM

Pearl Highlands Station Freeway Ramp Operation and Safety Analysis Report
Honolulu High-Capacity Transit Corridor Project

Appendix A-1
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Figure A-2. 2030 AM

LEGEND

(XXX)	A.M. Peak-Hour Volumes without the Project
XXX	A.M. Peak-Hour Volumes with the Project
	The Project
	Fixed Guideway Station
	Park-and-Ride Access Ramp (Elevated)
	Park-and-Ride Access Ramp (On Fill)
	Parking Structure and Bus Transit Center Structure

N

0   500   1,000 Feet

Pearl Highlands

Leeward Community College

Kamehameha Hwy

Farrington Hwy

Waiawa Rd

Ala 'Ike

H-1

H-2

Cane Haul Rd

Waikona St

Lumiaina St

Kahualena St
Kahualoa St
Waipahu St
Kahuanani St

(7000)
6800

(620)
530

(860)
860

(55)
400

(1715)
1665

40 15 20 35

330

115

85

15

(2070)
1975

345

(515)
470

(1555)
1505

(1770)
1720

240

(3545)
3450

(5440)
5440

(5025)
4785

(415)
655

(1260)
1260

(1060)
970

(420)
420

(50)
50

(365)
365

Appendix A-2
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Pearl Highlands Station Freeway Ramp Operation and Safety Analysis Report
Honolulu High-Capacity Transit Corridor Project

AR00113824

Figure A-3. 2030 PM

Pearl Highlands Station Freeway Ramp Operation and Safety Analysis Report
Honolulu High-Capacity Transit Corridor Project

Appendix B—HCS Analysis Results

Figure B-1. Merge Analysis: On-ramp from Kamehameha Highway with Westbound H-1 to Northbound H-2—2030 No Build PM Peak

RAMPS AND RAMP JUNCTIONS WORKSHEET		

General Information / **Site Information**

General Information		Site Information	
Analyst	Ryan Avery	Freeway/Dir of Travel	H2
Agency or Company	PB	Junction	Kamehameha Hwy
Date Performed	01/29/2010	Jurisdiction	Honolulu
Analysis Time Period	PM Peak	Analysis Year	2030
Project Description	No-Build		

Inputs

Upstream Adj Ramp	Terrain: Grade	Downstream Adj Ramp
☐ Yes ☐ On		☑ Yes ☑ On
☑ No ☐ Off		☐ No ☐ Off
L_{up} = ft		L_{down} = 1200 ft
V_u = veh/h	S_{FF} = 55.0 mph S_{FR} = 45.0 mph Sketch (show lanes, L_A, L_D, V_R, V_f)	V_D = 1800 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	3545	0.95	Grade	2	0	0.990	1.00	3769
Ramp	860	0.95	Grade	2	0	0.980	1.00	923
UpStream								
DownStream	1800	0.95	Grade	2	0	0.990	1.00	1914

Merge Areas	Diverge Areas

Estimation of v_{12} (Merge Areas)

$$V_{12} = V_F (P_{FM})$$

L_{EQ} =	(Equation 25-2 or 25-3)
P_{FM} =	1.000 using Equation (Exhibit 25-5)
V_{12} =	3769 pc/h
V_3 or V_{av34}	0 pc/h (Equation 25-4 or 25-5)
Is V_3 or V_{av34} > 2,700 pc/h?	☐ Yes ☑ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2	☐ Yes ☑ No
If Yes, V_{12a} =	pc/h (Equation 25-8)

Estimation of v_{12} (Diverge Areas)

$$V_{12} = V_R + (V_F - V_R)P_{FD}$$

L_{EQ} =	(Equation 25-8 or 25-9)
P_{FD} =	using Equation (Exhibit 25-12)
V_{12} =	pc/h
V_3 or V_{av34}	pc/h (Equation 25-15 or 25-16)
Is V_3 or V_{av34} > 2,700 pc/h?	☐ Yes ☐ No
Is V_3 or V_{av34} > 1.5 * V_{12}/2	☐ Yes ☐ No
If Yes, V_{12a} =	pc/h (Equation 25-18)

Capacity Checks (Merge)

	Actual	Capacity	LOS F?
V_{FO}	4692	Exhibit 25-7	Yes

Capacity Checks (Diverge)

	Actual	Capacity	LOS F?
V_F		Exhibit 25-14	
$V_{FO} = V_F - V_R$		Exhibit 25-14	
V_R		Exhibit 25-3	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
V_{R12}	4692	Exhibit 25-7 4600:All	No

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
V_{12}		Exhibit 25-14	

Level of Service Determination (if not F) (Merge)

$$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$$

D_R =	39.8 (pc/mi/n)
LOS =	F (Exhibit 25-4)

Level of Service Determination (if not F) (Diverge)

$$D_R = 4.252 + 0.0086\, V_{12} - 0.0009\, L_D$$

D_R =	(pc/mi/n)
LOS =	(Exhibit 25-4)

Speed Determination (Merge)

M_S =	0.718 (Exhibit 25-19)
S_R =	45.7 mph (Exhibit 25-19)
S_0 =	N/A mph (Exhibit 25-19)
S =	45.7 mph (Exhibit 25-14)

Speed Determination (Diverge)

D_s =	(Exhibit 25-19)
S_R =	mph (Exhibit 25-19)
S_0 =	mph (Exhibit 25-19)
S =	mph (Exhibit 25-15)

Pearl Highlands Station Freeway Ramp Operation and Safety Analysis Report
Honolulu High-Capacity Transit Corridor Project

Appendix B-1
March 3, 2010

Figure B-2. Merge Analysis: On-ramp from Kamehameha Highway with Westbound H-1 to Northbound H-2—2030 Build PM Peak

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information

		Site Information	
Analyst	Ryan Avery	Freeway/Dir of Travel	H2
Agency or Company	PB	Junction	Kamehameha Hwy
Date Performed	01/29/2010	Jurisdiction	Honolulu
Analysis Time Period	PM Peak	Analysis Year	2030

Project Description Build

Inputs

Upstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} =   ft

V_u =   veh/h

Terrain: Grade

S_{FF} = 55.0 mph S_{FR} = 45.0 mph

Sketch (show lanes, L_A, L_D, V_R, V_f)

Downstream Adj Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 1200 ft

V_D = 1800 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	3245	0.95	Grade	2	0	0.990	1.00	3450
Ramp	1060	0.95	Grade	5	0	0.976	1.00	1144
UpStream								
DownStream	1800	0.95	Grade	2	0	0.990	1.00	1914

Merge Areas	**Diverge Areas**

Estimation of v_{12}

$V_{12} = V_F(P_{FM})$

L_{EQ} =   (Equation 25-2 or 25-3)

P_{FM} = 1.000 using Equation (Exhibit 25-5)

V_{12} = 3450 pc/h

V_3 or V_{av34} 0 pc/h (Equation 25-4 or 25-5)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 • V_{12}/2 ☐ Yes ☑ No

If Yes,V_{12a} =   pc/h (Equation 25-8)

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} =   (Equation 25-8 or 25-9)

P_{FD} =   using Equation (Exhibit 25-12)

V_{12} =   pc/h

V_3 or V_{av34} pc/h (Equation 25-15 or 25-16)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 • V_{12}/2 ☐ Yes ☐ No

If Yes,V_{12a} =   pc/h (Equation 25-18)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	4594	Exhibit 25-7		Yes

Capacity Checks

		Actual	Capacity	LOS F?
V_F			Exhibit 25-14	
$V_{FO} = V_F - V_R$			Exhibit 25-14	
V_R			Exhibit 25-3	

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	4594	Exhibit 25-7	4600:All	No

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
V_{12}		Exhibit 25-14	

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734 v_R + 0.0078 V_{12} - 0.00627 L_A$

D_R = 38.8 (pc/mi/ln)

LOS = F (Exhibit 25-4)

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086 V_{12} - 0.0009 L_D$

D_R =   (pc/mi/ln)

LOS =   (Exhibit 25-4)

Speed Determination

M_S = 0.678 (Exibit 25-19)

S_R = 46.2 mph (Exhibit 25-19)

S_0 = N/A mph (Exhibit 25-19)

S = 46.2 mph (Exhibit 25-14)

Speed Determination

D_s =   (Exhibit 25-19)

S_R =   mph (Exhibit 25-19)

S_0 =   mph (Exhibit 25-19)

S =   mph (Exhibit 25-15)

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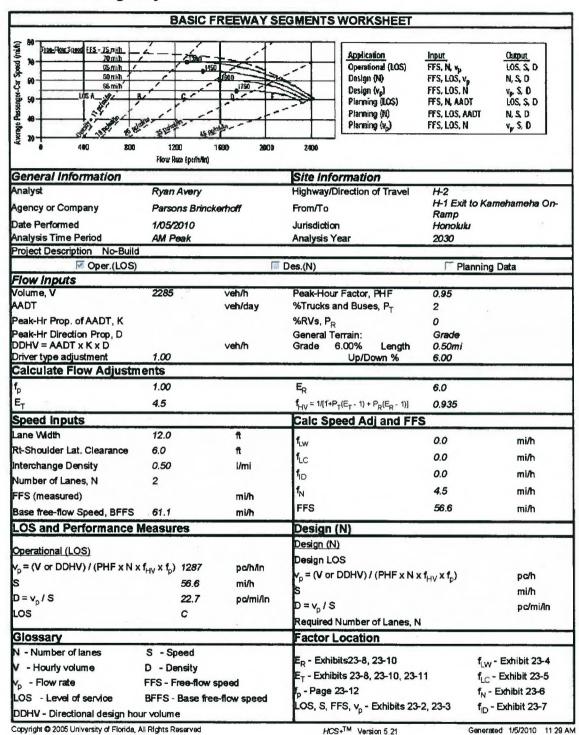Honolulu High-Capacity Transit Corridor Project

Appendix B-2
March 3, 2010

Figure B-3. Freeway Analysis: Northbound H-2 North of On-ramp from Kamehameha Highway—2030 No Build AM Peak

BASIC FREEWAY SEGMENTS WORKSHEET

Application	Input	Output
Operational (LOS)	FFS, N, v_p	LOS, S, D
Design (N)	FFS, LOS, v_p	N, S, D
Design (v_p)	FFS, LOS, N	v_p, S, D
Planning (LOS)	FFS, N, AADT	LOS, S, D
Planning (N)	FFS, LOS, AADT	N, S, D
Planning (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst	Ryan Avery
Agency or Company	Parsons Brinckerhoff
Date Performed	1/05/2010
Analysis Time Period	AM Peak

Project Description   No-Build

Site Information

Highway/Direction of Travel	H-2
From/To	H-1 Exit to Kamehameha On-Ramp
Jurisdiction	Honolulu
Analysis Year	2030

☑ Oper.(LOS)   ☐ Des.(N)   ☐ Planning Data

Flow Inputs

Volume, V	2285	veh/h	Peak-Hour Factor, PHF	0.95
AADT		veh/day	%Trucks and Buses, P_T	2
Peak-Hr Prop. of AADT, K			%RVs, P_R	0
Peak-Hr Direction Prop, D			General Terrain:	Grade
DDHV = AADT x K x D		veh/h	Grade 6.00% Length	0.50mi
Driver type adjustment	1.00		Up/Down %	6.00

Calculate Flow Adjustments

f_p	1.00	E_R	6.0
E_T	4.5	$f_{HV} = 1/[1+P_T(E_T-1)+P_R(E_R-1)]$	0.935

Speed Inputs

Lane Width	12.0	ft
Rt-Shoulder Lat. Clearance	6.0	ft
Interchange Density	0.50	l/mi
Number of Lanes, N	2	
FFS (measured)		mi/h
Base free-flow Speed, BFFS	61.1	mi/h

Calc Speed Adj and FFS

f_{LW}	0.0	mi/h
f_{LC}	0.0	mi/h
f_{ID}	0.0	mi/h
f_N	4.5	mi/h
FFS	56.6	mi/h

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	1287	pc/h/ln
S	56.6	mi/h
D = v_p / S	22.7	pc/mi/ln
LOS	C	

Design (N)

Design (N)

Design LOS

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)		pc/h
S		mi/h
D = v_p / S		pc/mi/ln
Required Number of Lanes, N		

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 23-8, 23-10	f_{LW} - Exhibit 23-4
E_T - Exhibits 23-8, 23-10, 23-11	f_{LC} - Exhibit 23-5
f_p - Page 23-12	f_N - Exhibit 23-6
LOS, S, FFS, v_p - Exhibits 23-2, 23-3	f_{ID} - Exhibit 23-7

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Appendix B-3
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Figure B-4. Freeway Analysis: Northbound H-2 North of On-ramp from Kamehameha Highway—2030 Build AM Peak

BASIC FREEWAY SEGMENTS WORKSHEET

Application	Input	Output
Operational (LOS)	FFS, N, v_p	LOS, S, D
Design (N)	FFS, LOS, v_p	N, S, D
Design (v_p)	FFS, LOS, N	v_p, S, D
Planning (LOS)	FFS, N, AADT	LOS, S, D
Planning (N)	FFS, LOS, AADT	N, S, D
Planning (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst	Ryan Avery
Agency or Company	Parsons Brinckerhoff
Date Performed	1/05/2010
Analysis Time Period	AM Peak

Site Information

Highway/Direction of Travel	H-2
From/To	H-1 Exit to Kamehameha On-Ramp
Jurisdiction	Honolulu
Analysis Year	2030

Project Description   Re-stripe bridge

☑ Oper.(LOS)　　　　　　☐ Des.(N)　　　　　　☐ Planning Data

Flow Inputs

Volume, V	2190	veh/h	Peak-Hour Factor, PHF	0.95	
AADT		veh/day	%Trucks and Buses, P_T	2	
Peak-Hr Prop. of AADT, K			%RVs, P_R	0	
Peak-Hr Direction Prop, D			General Terrain:	Grade	
DDHV = AADT x K x D		veh/h	Grade 6.00% Length	0.50mi	
Driver type adjustment	1.00		Up/Down %	6.00	

Calculate Flow Adjustments

f_p	1.00		E_R	6.0
E_T	4.5		$f_{HV} = 1/[1 + P_T(E_T - 1) + P_R(E_R - 1)]$	0.935

Speed Inputs

Lane Width	11.0	ft
Rt-Shoulder Lat. Clearance	3.0	ft
Interchange Density	0.50	I/mi
Number of Lanes, N	3	
FFS (measured)		mi/h
Base free-flow Speed, BFFS	61.1	mi/h

Calc Speed Adj and FFS

f_{LW}	1.9	mi/h
f_{LC}	1.2	mi/h
f_{ID}	0.0	mi/h
f_N	3.0	mi/h
FFS	55.0	mi/h

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	822	pc/h/ln
S	55.0	mi/h
D = v_p / S	14.9	pc/mi/ln
LOS	B	

Design (N)

Design (N)

Design LOS

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)		pc/h
S		mi/h
D = v_p / S		pc/mi/ln
Required Number of Lanes, N		

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 23-8, 23-10	f_{LW} - Exhibit 23-4
E_T - Exhibits 23-8, 23-10, 23-11	f_{LC} - Exhibit 23-5
f_p - Page 23-12	f_N - Exhibit 23-6
LOS, S, FFS, v_p - Exhibits 23-2, 23-3	f_{ID} - Exhibit 23-7

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Figure B-5. Merge Analysis: Northbound H-2 North of On-ramp from Kamehameha Highway—2030 No Build PM Peak

BASIC FREEWAY SEGMENTS WORKSHEET

Application	Input	Output
Operational (LOS)	FFS, N, v_p	LOS, S, D
Design (N)	FFS, LOS, v_p	N, S, D
Design (v_p)	FFS, LOS, N	v_p, S, D
Planning (LOS)	FFS, N, AADT	LOS, S, D
Planning (N)	FFS, LOS, AADT	N, S, D
Planning (v_p)	FFS, LOS, N	v_p, S, D

General Information			Site Information	
Analyst	Ryan Avery		Highway/Direction of Travel	H-2
Agency or Company	Parsons Brinckerhoff		From/To	H-1 Exit to Kamehameha On-Ramp
Date Performed	1/05/2010		Jurisdiction	Honolulu
Analysis Time Period	PM Peak		Analysis Year	2030
Project Description	No-Build			

☑ Oper.(LOS)	☐ Des.(N)	☐ Planning Data

Flow Inputs

Volume, V	4405	veh/h	Peak-Hour Factor, PHF	0.95
AADT		veh/day	%Trucks and Buses, P_T	2
Peak-Hr Prop. of AADT, K			%RVs, P_R	0
Peak-Hr Direction Prop, D			General Terrain:	Grade
DDHV = AADT x K x D		veh/h	Grade 6.00% Length	0.50mi
Driver type adjustment	1.00		Up/Down %	6.00

Calculate Flow Adjustments

f_p	1.00		E_R	6.0
E_T	4.5		$f_{HV} = 1/[1+P_T(E_T - 1) + P_R(E_R - 1)]$	0.935

Speed Inputs | ### Calc Speed Adj and FFS

Lane Width	12.0	ft	f_{LW}	0.0	mi/h
Rt-Shoulder Lat. Clearance	6.0	ft	f_{LC}	0.0	mi/h
Interchange Density	0.50	l/mi	f_{ID}	0.0	mi/h
Number of Lanes, N	2		f_N	4.5	mi/h
FFS (measured)		mi/h	FFS	56.6	mi/h
Base free-flow Speed, BFFS	61.1	mi/h			

LOS and Performance Measures | ### Design (N)

Operational (LOS)

$v_p = (V \text{ or } DDHV) / (PHF \times N \times f_{HV} \times f_p)$	2481	pc/h/ln
S		mi/h
$D = v_p / S$		pc/mi/ln
LOS	F	

Design (N)

Design LOS

$v_p = (V \text{ or } DDHV) / (PHF \times N \times f_{HV} \times f_p)$		pc/h
S		mi/h
$D = v_p / S$		pc/mi/ln
Required Number of Lanes, N		

Glossary | ### Factor Location

N - Number of lanes	S - Speed	
V - Hourly volume	D - Density	
v_p - Flow rate	FFS - Free-flow speed	
LOS - Level of service	BFFS - Base free-flow speed	
DDHV - Directional design hour volume		

E_R - Exhibits 23-8, 23-10	f_{LW} - Exhibit 23-4
E_T - Exhibits 23-8, 23-10, 23-11	f_{LC} - Exhibit 23-5
f_p - Page 23-12	f_N - Exhibit 23-6
LOS, S, FFS, v_p - Exhibits 23-2, 23-3	f_{ID} - Exhibit 23-7

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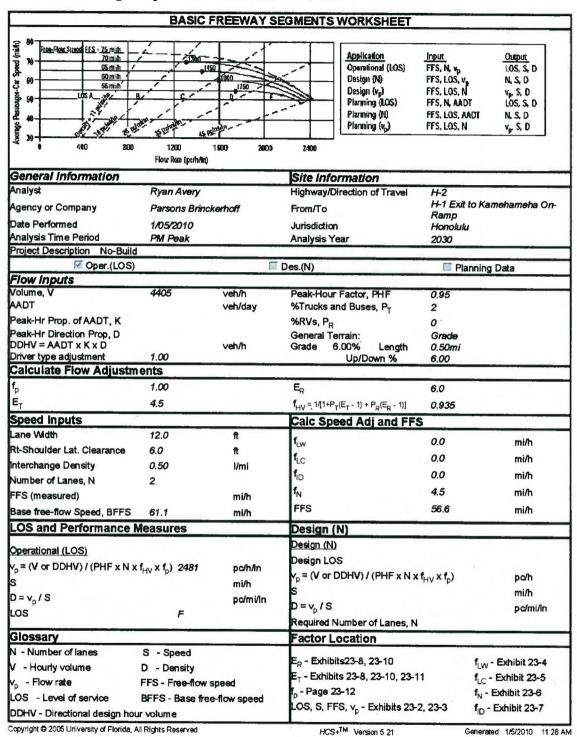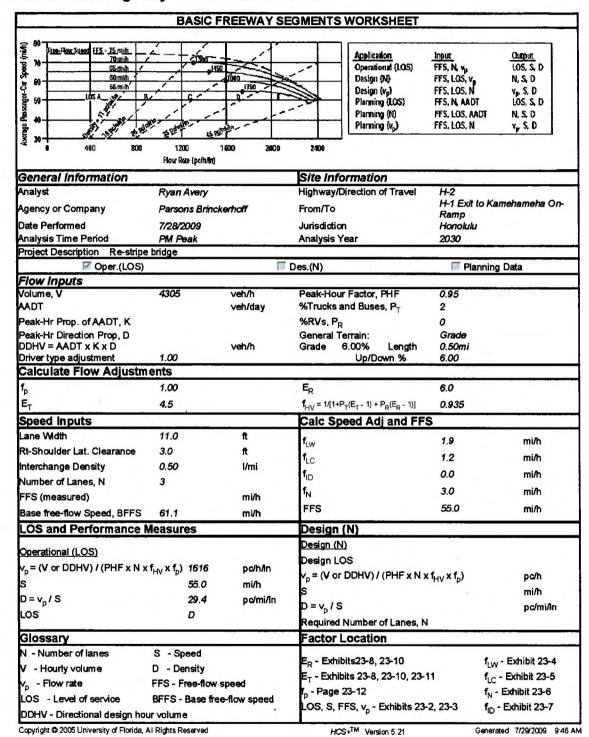## Figure B-6. Merge Analysis: Northbound H-2 North of On-ramp from Kamehameha Highway—2030 Build PM Peak

BASIC FREEWAY SEGMENTS WORKSHEET

Application	Input	Output
Operational (LOS)	FFS, N, v_p	LOS, S, D
Design (N)	FFS, LOS, v_p	N, S, D
Design (v_p)	FFS, LOS, N	v_p, S, D
Planning (LOS)	FFS, N, AADT	LOS, S, D
Planning (N)	FFS, LOS, AADT	N, S, D
Planning (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst	Ryan Avery
Agency or Company	Parsons Brinckerhoff
Date Performed	7/28/2009
Analysis Time Period	PM Peak

Project Description   Re-stripe bridge

Site Information

Highway/Direction of Travel	H-2
From/To	H-1 Exit to Kamehameha On-Ramp
Jurisdiction	Honolulu
Analysis Year	2030

☑ Oper.(LOS)   ☐ Des.(N)   ☐ Planning Data

Flow Inputs

Volume, V	4305	veh/h	Peak-Hour Factor, PHF	0.95
AADT		veh/day	%Trucks and Buses, P_T	2
Peak-Hr Prop. of AADT, K			%RVs, P_R	0
Peak-Hr Direction Prop, D			General Terrain:	Grade
DDHV = AADT x K x D		veh/h	Grade 6.00% Length	0.50mi
Driver type adjustment	1.00		Up/Down %	6.00

Calculate Flow Adjustments

f_p	1.00	E_R	6.0
E_T	4.5	$f_{HV} = 1/[1+P_T(E_T-1) + P_R(E_R-1)]$	0.935

Speed Inputs

Lane Width	11.0	ft
Rt-Shoulder Lat. Clearance	3.0	ft
Interchange Density	0.50	I/mi
Number of Lanes, N	3	
FFS (measured)		mi/h
Base free-flow Speed, BFFS	61.1	mi/h

Calc Speed Adj and FFS

f_{LW}	1.9	mi/h
f_{LC}	1.2	mi/h
f_{ID}	0.0	mi/h
f_N	3.0	mi/h
FFS	55.0	mi/h

LOS and Performance Measures

Operational (LOS)

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)	1616	pc/h/ln
S	55.0	mi/h
D = v_p / S	29.4	pc/mi/ln
LOS	D	

Design (N)

Design (N)

Design LOS

v_p = (V or DDHV) / (PHF x N x f_{HV} x f_p)		pc/h
S		mi/h
D = v_p / S		pc/mi/ln
Required Number of Lanes, N		

Glossary

N - Number of lanes	S - Speed
V - Hourly volume	D - Density
v_p - Flow rate	FFS - Free-flow speed
LOS - Level of service	BFFS - Base free-flow speed
DDHV - Directional design hour volume	

Factor Location

E_R - Exhibits 23-8, 23-10	f_{LW} - Exhibit 23-4
E_T - Exhibits 23-8, 23-10, 23-11	f_{LC} - Exhibit 23-5
f_p - Page 23-12	f_N - Exhibit 23-6
LOS, S, FFS, v_p - Exhibits 23-2, 23-3	f_{ID} - Exhibit 23-7

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Appendix C—Proposed H-2 Northbound Freeway Restriping Plan

Existing On-Ramp
From Kamehameha Hwy

Existing Connector Ramp
from H-1 Freeway Outbound

Existing Connector Ramp
from H-1 Freeway Inbound

Existing Connector Ramp
from H-2 Freeway Inbound

Proposed Off-Ramp to
Pearl Highlands Park&Ride

Min Acceleration Lenth Required
ACCORDING to Lenth Provided = 180-550'
500' Acceleration Lane

550' Taper Length

14.67'
11.98'
13.32'

8.48'
11.00'
11.00'

2.0'
11.00'
11.00'

40'   0   40'

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Appendix C-1
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